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REVIEWS.

Great Valley of California; a Criticism of the Theory of Isostasy, by F. LESLIE RANSOME: Univ. California, Bull. Geol. Dept., Vol. I, pp. 371–428, 1896.

British Geology, by T. MELLARD READE: Geological Magazine, Dec. 4, Vol. II, pp. 557–565, 1895.

Notes on the Gravity Determinations Reported by Mr. G. R. Putnam, by GROVE KARL GILBERT: Bull. Philos. Soc. Washington, Vol. XIII, pp. 61–76, 1895.

Three papers have been issued recently which have a direct bearing upon the theory of isostasy. Two are of the nature of criticisms; one being the outcome of studies conducted in this country, and the other of inquiries instituted in England. The third introduces some new complications which the advocates of the hypothesis would hardly expect.

The first memoir is of more than ordinary interest in being an attempt to practically test the theory from a purely geological standpoint, and to apply the principles to a particular limited region unusually favorably situated for obtaining tangible results. The paper had its origin in a review of the literature bearing upon the theory of "conservation of equilibrium in the earth's external form, which Dutton has named Isostasy, and which has come into prominence mainly through the labors of that illustrious group of American geologists to whom geology is so deeply indebted for certain broad views and far-sighted generalizations, which in spirit and expression recall the wide regions and clear atmosphere in which the authors worked."

Accordingly the discussion is appropriately subdivided into five distinct parts, (1) a description of the Great Valley as it is today, (2) an outline of the geological evolution through which it has arrived at its present form, (3) an account of the development of the so-called "doctrine of isostasy" as a working hypothesis, (4) a discussion of the applicability of this hypothesis to the Great Valley, and (5) a more general discussion of the theory of isostasy, with illustrations drawn from other regions of elevation or subsidence.

Before all, the physiographic features of the Great Valley are fully considered and the several parts in some detail. The main geological features are described and the evidence of several deep wells is brought in to show the composition of the strata underlying the region.

The geological history of the region is briefly and concisely related. This leads directly to the main theme—the principles of isostasy, for the Great Valley has an area in which there has been profound and progressive subsidence accompanied by great deposition. The literature relating to the theory is compactly brought together and summarized. The theory is then examined in the light of the facts derived from a study of the particular area.

The Great Valley represents a limited area in which 2000 feet of sediments were deposited at the same time that the rim was being raised. In explanation of the attendant phenomena the hypothesis of isostasy is not only regarded as unnecessary, but the facts presented are thought to directly oppose the idea of isostatic subsidence. A consideration of the essential features of isostasy shows it to be merely an hypothesis of readjustment and not of initial movement. It can operate only after conditions have become unstable. So far as applied to the Great Valley it is shown conclusively that the orogenic movements elevating the Coast Range began before the "formation of the valley and are consequently independent of any loading and subsidence." A little latter the Sierra Nevada range began to rise and in the great syncline between were deposited shallow water sediments to a depth of 2000 feet. Other facts are enumerated that are believed to be opposed to the hypothesis of isostatic movement in the valley. Several Californian areas are also brought in as presenting phenomena perfectly inexplicable upon the isostatic principle. After passing them the general discussion of the theory as a whole is reached.

In discussing the data upon which the theory has been made to rest specific cases are taken up. McGee's consideration of the Gulf of Mexico and the great Mississippi embayment receive particular attention. It is not, however, with the acumen shown in the other parts of the memoir. Some of the very objections urged against the region having subsided by loading are themselves so manifestly defective that they have the very opposite effect from that intended and naturally strengthen the hypothesis rather than weaken it. One point in particular may be noted: "The Mississippi River, during later geological times, has pushed its delta from Cairo out to its present termination in the Gulf of Mexico, an extension that is not compatible with the idea of *pari passu* local sinking under load, but which indicates a subsidence of more general extent, and independent of such local loading, inasmuch as the maximum effect has been, not near Cairo, at the original point of loading, but to the south of it—probably in the deep hollows of the present Gulf of Mexico. The river did not stop to build up a thick mass of delta accumulations at Cairo, as it should have done according to the theory of isostasy; but, attracted onward by the independent subsidence to the south it has covered the floor of the valley with relatively thin deposits only, and advanced persistently out into the Gulf."

Now the real reason that the Mississippi River did not build up a thick mass of delta accumulations at the head of the present embayment, "as it should have done according to the theory of isostasy" is that Cairo is probably not only not "the original point of loading," but the latter point is to the south of it, far to the south, in fact nearly as far as New Orleans. This is at once apparent from a glance at the history of the region. At the close of the Cretaceous or early in the Tertiary the whole region was a vast graded surface, or peneplain, the southern limit of which was as far south at least as central Louisiana. The present Mississippi River was a comparative insignificant stream with none of its present tributaries beyond the present city of St. Louis. The peneplain is found on the east side of the embayment dipping westward and on the west side dipping eastward under the unconsolidated clastics of the embayment, thus forming a broad shallow syncline, as recently shown by Griswold. The warping which has taken place since the beginning of this down-sinking along the line of the Mississippi has allowed a relatively thin mantle of later sediments to be deposited over a large area. While at various times the waters of a shallow sea may have been extended over a considerable portion of the embayment "the original point of loading" was doubtless not so very far from where it should be, nor is the present point of maximum depression and maximum loading far from "where it should be according to the theory of isostasy." This, it may be added introduces factors that are not commonly taken into account in the consideration of the genesis of large deltas.

Most of the other objections to the hypothesis of isostasy are well formulated and some of them appear unsurmountable.

In conclusion the author says: "The considerations presented in the foregoing paper indicate that, while the greater inequalities of the earth's surface, such as the continental arches and the oceanic depressions, may exist by reason of isostasy, the mass of available evidence is opposed to the view that denudation and sedimentation are able to produce movements in the earth's crust, as direct consequences of the weight of the material shifted. Not only do such superficial processes seem inadequate to initiate deep-seated crustal movements, but, as far as we can see, the movements, even when initiated through other causes, are as indifferent to such processes as is a slumbering volcano to the changes wrought by human tillage upon its flanks."

Mr. Reade's most recent references to the hypothesis of isostasy are contained in the presidential address to the Liverpool Geological Society in which he describes briefly the geology of the British Isles in relation to mountain building. The allusions to isostasy are incidental rather than specific and the conclusions to be deduced are against the theory. In this connection he gives a summary of his latest opinions regarding the cause of orogenic movements and ascribes them entirely to changes of temperature, producing expansion and contraction, and not to the shrinkage of the nucleus of the earth, the closing in of the non-shrinking crust upon it and the consequent folding by tangential pressure. In concluding he says: that "Neither does the principle of isostasy so insisted upon by American geologists explain the compression, folding and building up of great masses of sediment into mountain ranges. On the principle of isostasy, it must be obvious to anyone possessing even a rudimentary acquaintance with mechanics that the sinking of the bed of the seas on which great deposits are accumulating, and to some extent a rise of surrounding land, may be explained, but not the lateral compression and elevation of the sediments themselves into mountain ranges."

Mr. Gilbert's notes are of great interest at this time. They are based upon a series of trans-continental gravity determinations made by Mr. G. R. Putnam, and are appended to the latter's article. As generally understood isostasy is intended to cover those oscillations which are the direct result of local or provincial loading and unloading. This appears to be the specific limitation placed upon the hypothesis by Messrs. Dutton and McGee. Mr. Gilbert, however, uses the term in the present case in the broadest sense. He starts out by postulating general isostasy thus making the term nearly equivalent to a universal static conservation. His theme is stated as follows: "Let us postulate that the greatest features of the earth's relief, such as continents and great plateaus, are sustained isostatically, and that the small features, such as hills and small mountains, are within the competence of terrestrial rigidity, and then let us inquire what the pendulum work of the Coast Survey has to tell of the status of features of intermediate size, namely the greater mountains and smaller plateaus."

After describing the methods followed in making the determinations the details of the various stations at which pendulum measurements were made are discussed. Although the results of the calculations deviate greatly from what would be expected according to the hypothesis of isostasy the measurements are found to be "six times as discordant from the point of view of rigidity as they are from the point of view of isostasy."

In conclusion it is stated that the "measurements of gravity appear far more harmonious when the method of reduction postulates isostasy than when it postulates high rigidity. Nearly all the local peculiarities of gravity admit of simple and rational explanation on the theory that the continent as a whole is approximately isostatic, and that the interior plain is almost perfectly isostatic. Most of the deviations from the normal arise from excess of matter and are associated with uplift. The Appalachian and Rocky Mountains and the Wasatch plateau all appear to be of the nature of added loads, the whole mass above the neighboring plains being rigidly upheld. The Colorado plateau province seems to have an excess of matter, and the Desert Range province may also be overloaded. The fact that the six stations from Pike's Peak to Salt Lake City, covering a distance of 375 miles, show an average excess of 1345 rock-feet indicates greater sustaining power than is ordinarily ascribed to the lithosphere by the advocates of isostasy."

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Text-Book of Palæontology. Vol. I., Part I. By KARL A. VON ZITTEL. Translated and edited by CHARLES R. EASTMAN, PH.D. London: Macmillan & Co., Ltd., 1896.

An English edition of von Zittel's *Paläontologie* is the most welcome of palæontological works that has appeared in a long time. The